

WHAT IS CLAIMED IS:

1. A toroidal continuously variable transmission comprising:

5       an input disk to which rotation of a prime mover is transmitted;

an output disk coaxially arranged with and opposed to the input disk, the output disk adapted to have a driving connection with and to have a driven connection with a road wheel;

10      a power roller interposed between the input and output disks under axial preload for power transmission;

      a trunnion rotatably supporting the power roller to permit a tilting motion of the power roller about a trunnion axis perpendicular to a rotation axis of the power roller  
15   for ratio changing;

      a hydraulic servo mechanism connected to the trunnion to move the trunnion in a direction of the trunnion axis so as to cause the tilting motion of the power roller by creating an offset of the trunnion from a neutral position in the  
20   direction of the trunnion axis, the neutral position being a non-ratio-changing position at which the rotation axis of the power roller intersects a common rotation axis of the input and output disks;

25      a primary oil pump driven by the prime mover to produce a hydraulic pressure;

      a secondary oil pump driven in response to rotation of the road wheel to produce a hydraulic pressure;

      the hydraulic servo mechanism hydraulically operated by either of the hydraulic pressure from the primary oil pump  
30   and the hydraulic pressure from the secondary oil pump;

      a ratio-change-control hydraulic system that supplies the hydraulic pressure discharged from the secondary oil pump to the hydraulic servo mechanism to prevent the offset of the

trunnion in the trunnion-axis direction, corresponding to an upshift, occurring owing to rotation of the road wheel in a stopped state of the prime mover; and

the ratio-change-control hydraulic system by which a  
5 modulated hydraulic pressure is constantly produced and outputted to the secondary oil pump during operation of the primer mover to hold the secondary oil pump at an inoperative state during the operation of the prime mover.

10 2. The toroidal continuously variable transmission as claimed in claim 1, wherein:

a hydraulic pressure in a cooling-and-lubricating circuit of the ratio-change-control hydraulic system of the toroidal continuously variable transmission, which is modulated from  
15 the hydraulic pressure discharged from the primary oil pump, is used as the modulated hydraulic pressure constantly produced during operation of the primer mover.

3. The toroidal continuously variable transmission as  
20 claimed in claim 1, wherein:

a hydraulic pressure in a torque converter pressure circuit of the ratio-change-control hydraulic system of the toroidal continuously variable transmission, which is modulated from the hydraulic pressure discharged from the  
25 primary oil pump, is used as the modulated hydraulic pressure constantly produced during operation of the primer mover.

4. The toroidal continuously variable transmission as  
30 claimed in claim 1, wherein:

a hydraulic pressure in a line pressure circuit of the ratio-change-control hydraulic system of the toroidal continuously variable transmission, which is modulated from

the hydraulic pressure discharged from the primary oil pump, is used as the modulated hydraulic pressure constantly produced during operation of the primer mover.

- 5 5. The toroidal continuously variable transmission as claimed in claim 1, wherein:

a hydraulic pressure in a pilot pressure circuit of the ratio-change-control hydraulic system of the toroidal continuously variable transmission, which is modulated to a 10 constant pressure level by pressure-reducing a line pressure modulated from the hydraulic pressure discharged from the primary oil pump, is used as the modulated hydraulic pressure constantly produced during operation of the primer mover.

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6. The toroidal continuously variable transmission as claimed in claim 1, wherein:

the secondary oil pump comprises:

- (a) a pumping element; and  
20 (b) a pump driving element;

the secondary oil pump is held at the inoperative state by maintaining the pumping element in a spaced, contact-free relationship with the pump driving element by the modulated hydraulic pressure constantly produced during operation of 25 the primer mover.

7. The toroidal continuously variable transmission as claimed in claim 6, wherein:

- the secondary oil pump comprises a reciprocating pump 30 having a reciprocating pumping element; and  
the secondary oil pump is held at the inoperative state by holding the reciprocating pumping element at a stroke position where there is no motion transmission from the pump

driving element to the reciprocating pumping element, by the modulated hydraulic pressure constantly produced during operation of the primer mover.

5 8. The toroidal continuously variable transmission as claimed in claim 6, further comprising:

an actuator arranged close to the secondary oil pump and having a lock pin that is hydraulically operated by the modulated hydraulic pressure constantly produced during  
10 operation of the primer mover;

wherein the secondary oil pump comprises a reciprocating pump having a reciprocating pumping element formed with a pin slot; and

wherein the secondary oil pump is held at the inoperative  
15 state by holding the reciprocating pumping element at a stroke position where there is no motion transmission from the pump driving element to the reciprocating pumping element, by bringing the lock pin into engagement with the pin slot by application of the modulated hydraulic pressure,  
20 constantly produced during operation of the primer mover, to the actuator.

9. The toroidal continuously variable transmission as claimed in claim 1, wherein:

25 the secondary oil pump comprises a reciprocating pump, the reciprocating pump comprising:

(a) a reciprocating pumping element;

(b) a positive motion cam mechanism comprising:

(i) a positive motion cam serving as a pump

30 driving element and driven in response to rotation of the road wheel; and

(ii) a cam follower being conditioned in engagement with the positive motion cam in two opposite

directions of a stroke of the reciprocating pumping element to transmit input motion of the positive motion cam via the cam follower to the reciprocating pumping element in the opposite stroke directions; and

5 which further comprises:

a selector valve being responsive to the modulated hydraulic pressure constantly produced during operation of the primer mover, for switching from (i) a first operating mode at which a pumping action of the secondary oil pump is  
10 permitted to (ii) a second operating mode at which the secondary oil pump is held at an unloaded condition, instead of holding the secondary oil pump at the inoperative state by the modulated hydraulic pressure constantly produced during operation of the primer mover.

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10. The toroidal continuously variable transmission as claimed in claim 9, wherein:

the selector valve comprises a two-way three-port directional control valve having a pump port connected to an  
20 inlet port of the secondary oil pump, a suction port communicated with an oil-pan lower-level portion than an oil level of an oil pan, a drain port communicated with an oil-pan higher-level portion than the oil level of the oil pan, and a spring-loaded valve spool slidably movable between a  
25 first spool position corresponding to a spring-loaded position at which fluid communication between the inlet port of the secondary oil pump and the suction port of the selector valve is established to lead the inlet port to working fluid in the oil pan and a second spool position at  
30 which fluid communication between the inlet port of the secondary oil pump and the drain port of the selector valve is established to lead the inlet port to air in the oil pan.

11. The toroidal continuously variable transmission as claimed in claim 1, further comprising:

a feedback device through which a tendency of the offset of the trunnion in the trunnion-axis direction,  
5 corresponding to the upshift, is fed back to the hydraulic servo mechanism, so that the trunnion returns to the neutral position in presence of a drop in the hydraulic pressure discharged from the secondary oil pump during rotation of the road wheel in a reverse-rotational direction in the  
10 engine stopped state.

12. The toroidal continuously variable transmission as claimed in claim 1, wherein:

the hydraulic servo mechanism comprises:  
15 an axially slidable servo piston which is fixedly connected to the trunnion and by which a low-pressure chamber and a high-pressure chamber are defined; and  
which further comprises:  
a biasing device that is disposed in the low-pressure  
20 chamber to force the servo piston toward a stroke position corresponding to the neutral position of the trunnion, and to prevent a tendency of the offset of the trunnion in the trunnion-axis direction, corresponding to the upshift by returning the trunnion to the neutral position by a spring  
25 bias of the biasing device when the low-pressure chamber and the high-pressure chamber defined on both sides of the servo piston are held at non-pressure states during rotation of the road wheel in a normal-rotational direction in the engine stopped state.